Towards an Industrial Manufactured Morphing Trailing Edge Flap System for Wind Turbines

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Towards an Industrial Manufactured Morphing Trailing Edge Flap System for Wind Turbines

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Introduction

Several numerical studies in the past 10 years have shown big potentials for load reduction on MW turbines using distributed control for alleviation of the fluctuating loads along the blade span. However, the requirements by the wind turbine industry of robust actuator solutions where the strongest specifications mean no metal and electrical parts in the blades have so far limited the use of the smart blade technology on wind turbines.

In the 3½ year project INDUFLAP (2011-2024), funded by the Danish Energy Agency through the EUDP programme, a flap system developed at DTU and tested on a laboratory level, is transferred into an industrial manufacturing process and tested on a novel rotating test rig. **The industrial partners are Rehau, Hydratech Industries and Dansk Gummi Industri**.

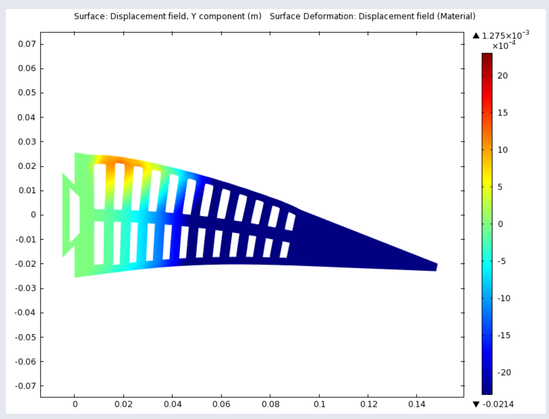
Objectives

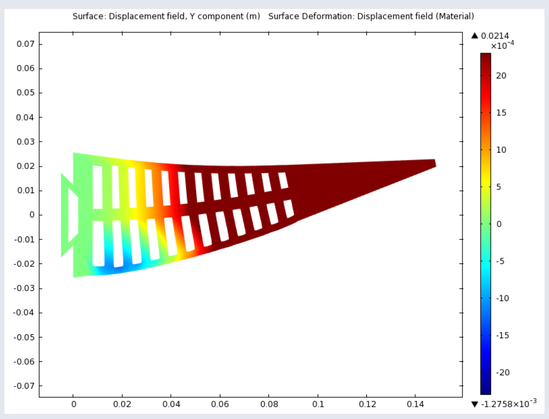
To develop a robust morphing trailing edge flap system characterized by:

- ❑ no mechanical parts in the blade
- ❑ no metal parts in the blade
- ❑ no electronics in the blade

The flap actuation concept

The flap system, with the first prototype developed and tested back in 2007, comprises a morphing trailing edge flap (e.g. 15% of the total chord) manufactured in an elastic material and with voids inside in two layers close to the pressure side and to the suction side, respectively. The voids can be pressurized with a fluid medium which can be air or a liquid. When one of the two layers is pressurized the flap deflects as illustrated below by the result of a COMSOL simulation.



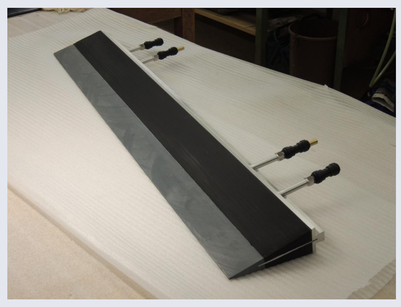


The industrial manufacturing process

The industrial production of flap prototypes has been performed at REHAU in kind of a multi component system comprising an enforcement structure and two elastic active elements regulated in deformation by a pressurized fluid medium. Fabrication of the active elements was performed by **a continuous thermoplastic extrusion process** in form of a quasi endless 12 chamber hollow profile. For manufacturing the sealed ends of the hollow profiles, a special method of a contact welding process has been developed.

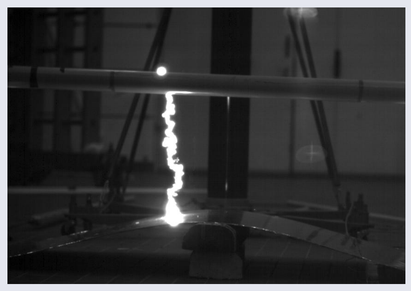
Process of mounting sealed ends:

- ❑ teflon coated heating plate
- ❑ Massive end cap (left side)
- ❑ Open end of hollow chamber profile (right side)



Lightning protection optimization

The flap system will be affected by direct and indirect effects of lightning discharges. The main measure to prevent direct lightning strikes to the flap system is the use suitable non-conductive materials, the breakdown and tracking resistance of which has been tested. The results of the tests show that the flap material has comparable properties to the fiberglass material used in blades, regarding the interaction with lightning.

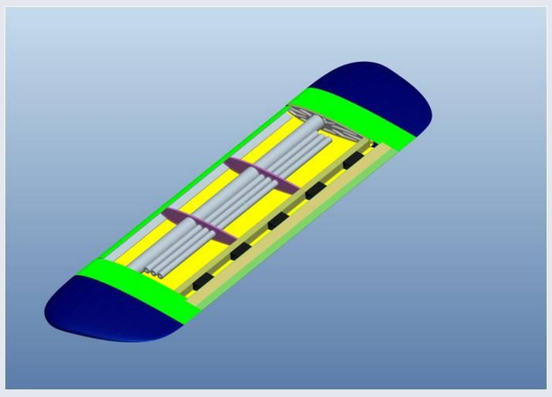


Rotating test rig

Testing the performance and robustness of the smart blade technology is another main part of the INDUFLAP project. Wind tunnel testing of the present flap technology was done back in 2009 and proved that the concept works. However, there is big step from wind tunnel testing to full scale turbine application and therefore a so-called **rotating test rig** has been developed in the INDUFLAP project.

The idea is that the testing should be as close as possible to the rotating test environment on the real turbine and have the same unsteady inflow conditions and a size of the flap not that far from full scale.

This has been obtained by manufacturing a blade section with a 1m chord and 2m span and mounting it on a 10m long boom as shown below. The boom will be mounted on the 100kW Tellus turbine in the spring 2014 instead of the normal three bladed rotor that was taken down in February 2013. Detailed testing will be carried out to document the flap performance including measurement of the pressure distribution on the blade section as well as inflow measurements with a five hole pitot tube.



Sketch of the 2m x 1m blade section

Blade section ready for mounting the flap

The rotating test rig is based on a 100kW turbine platform where a 10m long boom with the 2m x 1m blade section with flap is mounted instead of the normal three bladed rotor.

Future testing and development

The detailed testing of the flap system on the rotating test rig in the spring 2014 will be used for input to aeroelastic simulations of the load alleviation capability of the flap system on a full scale turbine. Finally, together with a cost model for the system this will enable the derivation of the cost competiveness of the flap system in comparison with the conventional pitch system.

After the end of the INDUFLAP project in the summer 2014 it is planned that the next step could be a test of the system on a full scale turbine, possibly by integrating the flap system on an existing rotor. **Interested partners for this final prototype testing of the system are welcome to contact the present project partners**. See below for contact details.

Contact

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